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The Measurement of Combat Stress in the Field: A Product Development Study

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INTRODUCTION

The Australian Defence Force has long maintained a technology gap over its regional neighbours. This has traditionally been in the area of principal items of equipment, the F111 aircraft, COLLINS class submarines, surveillance equipment, and so on. The strength of the Asian economies over the past two decades, and the concomitant growth in military spending in the region, (particularly on principal items) has seen this gap diminish.

One area that the Australian Army has traditionally seen as a comparative strength has been in the skills and training of the individual soldier. In the early nineties, however, a need was perceived to improve the individual combat capability of the infantry soldier in order to improve the combat capability of the Army as a whole. This led to the creation of Project WUNDURRA (an aboriginal word meaning "warrior"), which subsequently became known as Project LAND125 (Soldier Combat System Enhancement Study).

Project LAND125

LAND125 is a project being conducted jointly by the Australian Defence Force's Directorate of Trials, and the Defence Science and Technology Organizations (DSTO). The aim of the project is to identify technology enhancements that will contribute to improving the combat capability of the individual infantry soldier and his section (or squad). A number of technology enhancements are being considered in the project including night vision equipment, personal communications equipment, thermal weapons sights, and portable computers or hand-held data terminals (HHDT). The trial methodology being used for the Project is described as "model-test-model", where the performance of the soldier is computer modelled, then the enhancements are tested in the field to obtain more refined data to be input into subsequent computer models.

As part of the project, the Army's Directorate of Psychology was tasked to investigate the to identify the key psychological issues associated with the technology enhancements investigated in LAND125. This was interpreted to mean

identifying the impact the technology enhancements had on individual soldiers' ability to perform their duties; in other words, what stress does new technology place on soldiers, and what effect does this have on the performance of the soldiers' duties, and how can this be incorporated into the modelling process.

Stress is conceptualised as having four major manifestations: physical, mental, emotional, and behavioural. To identify the impact of this on soldiers' performance it is necessary to measure all four of these. This means bringing together a wide variety of disparate measures in an integrated form that is able to be used in a field environment. The aim of the current trial was to identify a methodology for achieving this.

METHOD

Sample

Soldiers from C Company of the 1st Battalion of the Royal Australian Regiment provided the sample for the trial. There were a total of 29 participants (ten each in the two sections and nine in the other section), all of whom were male with an average age of 23 years (standard deviation 2.8 years).

Measures

In order to determine whether measures could be made of all the manifestations of the stress response (physical, mental, emotional, and behavioural) a range of data were collected during the trial. The following data were collected:

- a. urinary cortisol;**
- b. salivary immunoglobulin levels (sIg);**
- c. soldier's mood, measured using the Profile of Mood States (POMS; McNair, Lorr and Droppelman, 1971);**
 - 1. general mental health and stress-related symptoms, measured using the GHQ (Goldberg 1972);**
 - 2. general cognitive ability, measured using a standard Army clerical ability, the ASA;**
- d. soldiers' attitudes to the equipment and the training they received, measured using the Solider Activity Survey (Little, 1998);**
- e. an HF questionnaire, developed to measure the attitudes of soldiers to the monitoring equipment, the tasks they were required to do, and their overall level of satisfaction with a specific set of experiments;**
- f. individual and group interviews, designed to complement the survey and**

questionnaire.

- g. a diary which recorded soldier's major activities during the day and any other relevant information; the aim of the trial diary was to provide corroborating information for the other stress measures, particularly the sIg assays.

Criterion Measures. One of the major components of the LAND125 project was the development of the Tactical Engagement Simulation System (TESS). This system is designed as a training aid, however it also provides a wide range of data on soldier performance in the field, including whether a soldier has been engaged by, or engages, the enemy, and to measure the effectiveness of this engagement. The data from TESS were planned to be used as criterion information for comparison of the effects of psychological stress on soldier performance.

Experimental Design

There were two distinct experimental designs used during the trial:

- a. The comparison design involved two sections, randomly allocated to either the Baseline (no enhancements) or the Enhanced (complete technological enhancements) condition, which were then compared on a number of variables. The sections completed a set of specific activities, aimed at acquiring data on specific military activities (e.g., a foot patrol in urban, open, and jungle terrain, a section attack, and so on). These were known as the OA or HFOA experiments.
- b. The within subjects design involved one section allocated to the Human Factors (HF) experiment and provided intra-individual comparisons in a repeated measures design. The HF experiment involved a patrol in both open and jungle terrain. During this experiment both psychological and physiological data was collected.

The work schedule for the sections involved one activity conducted twice each day, once in daylight, and a second time at night. The trial was conducted in the height of summer at the High Range Training Area near Townsville and the Land Command Battle School at Tully, both of which are in far north Queensland. The timing and location of the trial was aimed at maximising the environmental stressors on the equipment, High Range is very hot and dry in summer, while the Battle School is a jungle training area.

Data Collection Protocols

There were four data collection protocols used for the psychological human factors during LAND125 Trial 8/651. These were:

- a. Periodic data collection for the Baseline and Enhanced sections.
- b. Specific data collection for the OA experiments.
- c. Specific data collection for the HF experiments.
- d. Specific data collection for the HFOA experiments.

Periodic Data Collection. The aim of the periodic data collection was to determine methodologies for examining the longer term effects of technology enhancements on soldier stress. Data were collected prior to the trial starting and at regular intervals throughout the trial. The measures used in the periodic data collection were: sIg, POMS, GHQ, and ASA. As well, each soldier was required to update his trial diary as part of this data collection.

Specific Data Collection – OA Experiments. This protocol was aimed at determining whether it was possible to measure changes in the stress response over a specific, short duration, activity. There were not enough trials on each activity to compare all the activities, but it was believed that it is possible to determine whether the measuring instruments were effective over individual activities. The instruments used included the ASA, the POMS, the Soldier Activity Survey, focus groups, and individual interviews.

Specific Data Collection - HF Experiment. The aim of this data collection was to gather psychological stress measures to support data collection on the effects of heat stress on soldiers in order to compare psychological and physiological measures of stress. Instruments used in these experiments were the ASA, POMS, urinary cortisol, and the HF questionnaire.

Specific Data Collection - HFOA Experiment. The HFOA experiment was aimed at developing a multi-disciplinary approach to assess the effects of the technology enhancements trialled as part of LAND125. The psychological measures used for the HFOA experiment were the ASA and POMS. A range of physiological data were collected in these experiments also.

Analysis

Due to the small sample sizes, complex analyses were not appropriate, so, data analysis consisted primarily of comparisons of means, via t-tests or ANOVA, and crosstabulation analysis of counts where appropriate. Generally, a number of analyses were conducted for each experiment, which were aimed at comparing the different data collection methodologies rather than comparing treatment effects. In all cases it was only expected that the analyses would provide indicative results, the

aim of the study was, after all, to identify methodologies that were applicable in the field environment.

RESULTS

Despite the comments above regarding the effect of the small sample size on the value of the results, there were some statistically significant results that indicate that the instruments were capable of measuring differences between the groups in this environment. These will be reported in terms of the measures to which they pertain.

Subjective Measures of Stress

The subjective measures of stress were generally well received. The Soldier Activity Survey showed that soldiers were interested in voicing their opinion on the equipment and the training they had received. While initial analyses showed significant differences between the sections, as the trial progressed it became clear that the soldiers found the self-report instrument too long and repetitive, and that they preferred a focus group format.

The HF Questionnaire was effective in identifying differences in the perceptions of soldiers who were wearing different protective clothing. Soldiers wearing the extra protective equipment felt more uncomfortable in general and also felt that this was attributable to the equipment they were wearing, but perceived no difference in the difficulty of the tasks they were doing. The soldiers found the instrumentation intrusive, but adapted to it and were accepting of the need for such instrumentation. As a general finding, the soldiers felt that the activities in which they were participating were less difficult than they would normally expect.

The individual and group interviews confirmed the finding from the HF Questionnaire that the soldiers were not working very hard, and allowed the soldiers to address issues that were not otherwise considered anywhere else. This included the amount of time that night vision equipment could be used at night, and the importance of retaining visual contact with other members of the section (irrespective of the effectiveness of the intra-section communications).

The Trial Diary provided a very interesting comparison of the perceptions of the soldiers in the Enhanced and Baseline sections. The latter perceived themselves as working less hard and having much longer periods of light or sedentary duties than their peers in the Enhanced section. Further analysis of this type of information may contribute to better understanding of some of the other findings from the study.

Overall soldiers responded better in the interviews than the questionnaires, providing more information and greater insights. In general it would seem that, in the field situation, the strengths of the interview as a data collection tool outweigh its weaknesses (Watson, 1997). Soldiers were more willing to answer questions from the researcher than they were to respond to the surveys, and this was exacerbated when they were fatigued, as was usually the case immediately after the activities. It was quite noticable that, as the trial progressed, responses to the questionnaire became more extreme. This seemed to be clearly related to the fatigue of the soldiers, their familiarity with the instrument and their frustration with the paper-and-pencil format of the instrument.

Cognitive Measures

Pre-trial measures showed that significant differences existed between the Baseline and Enhanced groups, both in the number of correct responses (Baseline scored higher) and the number of errors (Baseline had more). Subsequent measures of the OA experiment showed that while the difference in error rate remained, the difference in score correct diminished, with the Enhanced section scores equaling the Baseline section scores. That is; over time any pre-trial differences between the Baseline and Enhanced sections disappeared.

Across the HF experiment there were inconsistent results for the number of correct responses to the ASA with the number correct increasing from the first to second experiment, but decreasing to below the initial result for the third experiment. The fourth and fifth measurements were almost identical. More consistent results for the number of errors showed a constant increase in the error rate across the experiments.

Psychometric Measures

Not all of the psychometric data from the trial has been analysed. Specifically, the results of the GHQ have not been analysed and will be discussed in a later publication. The POMS data have been afforded priority because of their widespread use in the international research domain (e.g., Fry, Grove, Morton, Zeroni Gaudieri & Keast, 1994) and the potential of the data identified in the 1997 trial (Little, 1998).

Comparison of the Baseline and Enhanced groups over the periodic data collection periods showed no significant differences between the two groups during the initial stages of the trial. However, the data from the first week of the Trial suggest that differences were beginning to emerge with the Enhanced section reporting higher tension, anger, and confusion scores. Significant differences between the two groups also become apparent at the end of the second week of the trial when the Enhanced

group scored higher on tension and depression than did the Baseline section. By the time the post-trial measures of mood were taken for both groups the only significant difference was that the Enhanced section reported feeling more fatigue than the baseline section although both groups reported the activity as being reasonably difficult.

Psychophysiological Measures

Results from the psychophysiological measures taken during the trial were inconclusive:

- a. Because of sampling problems, only the final set of slg samples were available for analysis.
- b. The results of the cortisol assays showed only a handful of soldiers with urinary cortisol concentrations higher than what is considered normal. The majority of the high cortisol levels occurred on the last day of the study which suggests that body armour and water bladder protocol resulted in greater stress on the subjects. However, fatigue due to four days of continuous activity cannot be ruled out.

Criterion Measures

No criterion information was available from the TESS equipment. Due to a number of technical problems reliable criterion information including number of shots fired, hits and near misses made, and hits and near misses received was unavailable. At the time there was little clear answer as to how the information had been corrupted, but suggestions included problems in the links with the equipment, to differences in the way the equipment was used by the soldiers. Data were available for some individuals, but the total absence of data for others makes the entire data set unreliable and unsuitable for use as criteria against which to compare the effects of stress.

Information was available from the SMEs as to the adequacy of the section's activities, but this tended to be more focussed on the group rather than looking at individual differences among soldiers, and was relatively unstructured and so more detailed analyses is difficult to perform on the data. As a result, while SME information can provide a useful insight into the section's performance, it is of less value when considering individual differences in the impact of psychological stress on soldier performance.

DISCUSSION

Overall the trial proved to be very successful in terms of identifying whether it was

possible to measure those aspects of psychological human factors that may be related to the technology enhancements involved in LAND125. Within this, there were a number of significant themes to emerge, these were:

- a. The subjective data collection indicated very clearly that the soldiers were not stressed a great deal during the Trial, and they were certainly not stressed as much as they would experience during an exercise or on operations. The conclusion to be drawn from this is that, because the soldiers are not experiencing a realistic level of stress, it is impossible to make any substantive decisions regarding the human performance dimension from this (or similar) trials.
- b. Despite the small sample sizes, noticable effects could be measured in a number of areas of stress symptoms. The measure of cognitive performance showed clear promise, as did the POMS, and the subjective measures. Further development of these should occur and the main focus should be on improving the delivery of these through improved automation.
- c. The small sample sizes were the source of some discussion about the experimental design used in the trial, particularly the difference between a between subjects and a within subjects design. There are clear research paradigm differences between the different scientific domains on this question (particularly physiology and psychology), however, there is clear value to be gained from an integration of the information gained from both areas. Future trials need to attempt to develop experimental designs that allow some compromise between the two approaches.
- d. While there are sound scientific and operational reasons to pursue the measurement of psychophysiological indicators of stress, there is a need to develop the data collection methodologies to make them practical to use in the field. At the moment this is not the case.
- e. There appears to be strong support for retaining qualitative data collection to support the quantitative data collection methods. Soldiers value it for giving them a direct line into the research process, and there may be issues that were not previously considered by the researchers that may only come up during this, less structured, form of data collection. However, there is a need to refine the qualitative data collection process in order to make it as efficient as possible.
- f. There is an imperative to develop adequate individual performance measures in the absence of adequate information from TESS, or other quantitative means. Data from SMEs may be used but would need to be more structures and focussed on individual differences rather than the section's performance.

Future Directions

There is a clear requirement to develop an automated means of capturing data in

the field. The results of this experiment showed that, while to content of the paper-and-pencil instruments was appropriate (both the cognitive and emotional instruments), the format is both clumsy to use in a field environment and poorly received by the soldiers. Our aim is to address this problem by transferring the psychometric and other paper-and-pencil instruments to a computer administered format, most likely on a handheld computer rather than a notebook or larger format machine to increase the robustness and useability in the field.

A second clear result of this trial is that the difficulty experienced collecting the psychophysiological measures indicates a better process is required, particularly considering the success of these measures on previous trials (Little, 1997). The development of a more robust method of taking these measures is currently being undertaken, and a trial version of this should be available in the first half of 1999. It is intended that this will be incorporated in future trials.

The responses to the subjective measures (interviews, focus groups, and diaries) all proved extremely valuable in providing information that was not easily available through other, more objective, means. There is a need, however, to review these measures to ensure that they are as efficient and as effective as possible. In particular there seems to be value in developing a structured interview based on the experiences of this trial.

The final indication of future developments is a procedural one. The developments mentioned above must be integrated into a package that can be used in the field by a small team of researchers attached to a unit during exercises (or even operations) with minimal intrusion on the operations of the unit. The experiment environment is simply not realistic enough to identify whether there are any psychological impacts of the equipment on the soldiers. There is a clear need to assess these effects in as realistic environment as possible.

Conclusion

The LAND125 trial was successful in identifying that it was feasible to measure the psychological impacts of technology enhancements in a field environment. There were a number of deficiencies identified, but solutions for these were identified during the trial and when addressed should result in a highly portable, integrated, automated measuring instrument that will contribute significantly to the success of the whole LAND125 process.

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